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Editors: Jacco van Loon and Albert Zijlstra

Editorial

Dear Colleagues,

It is a pleasure to present you the 179th issue of the AGB Newsletter. Among the other very interesting contributions, there is a series of papers on the thermohaline instability and rotation-induced mixing.

Austerity? Euro crisis? There are still jobs in astronomy! See for instance the advertisement of a postdoctoral position in Vienna.

The Fizeau exchange programme has another round of applications opening, and don't miss the announcement of the fascinating workshop on "radio stars".

The next issue is planned to be distributed on the 9th of July – a little later than usual as one of the editors will be running the Midnight Sun marathon and will need some time to recover.

Editorially Yours,
Jacco van Loon and Albert Zijlstra

Food for Thought

This month's thought-provoking statement is:

Within star clusters, AGB circumstellar envelopes are severely truncated

Reactions to this statement or suggestions for next month's statement can be e-mailed to agbnews@astro.keele.ac.uk (please state whether you wish to remain anonymous)

Refereed Journal Papers

Discovery of a compact companion to the hot subdwarf star BD +37°442

N. La Palombara[1], *S. Mereghetti*[1], *A. Tiengo*[1,2] *and P. Esposito*[3]

[1]INAF — IASF Milano, Italy
[2]IUSS Pavia, Italy
[3]INAF — Oss. Astron. Cagliari, Italy

We report the results of the first X-ray observation of the luminous and helium-rich O-type subdwarf BD +37°442, carried out with the XMM–*Newton* satellite in August 2011. X-ray emission is detected with a flux of about 3×10^{-14} erg cm^{-2} s^{-1} (0.2–1 keV) and a very soft spectrum, well fit by the sum of a blackbody with temperature $kT_{\rm BB}=45^{+11}_{-9}$ eV and a power law with a poorly constrained photon index. Significant pulsations with a period of 19.2 s are detected, indicating that the X-ray emission originates in a white dwarf or neutron star companion, most likely powered by accretion from the wind of BD +37°442.

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and from http://iopscience.iop.org/2041-8205/750/2/L34/

Thermohaline instability and rotation-induced mixing. I. Low- and intermediate-mass solar metallicity stars up to the end of the AGB

Corinne Charbonnel[1,2] *and Nadege Lagarde*[1]

[1]Geneva Observatory, University of Geneva, Chemin des Maillettes 51, 1290 Versoix, Switzerland
[2]Laboratoire d'Astrophysique de Toulouse–Tarbes, CNRS UMR 5572, Université de Toulouse, 14, Av. E. Belin, 31400 Toulouse, France

Context: Numerous spectroscopic observations provide compelling evidence for non-canonical processes that modify the surface abundances of low- and intermediate-mass stars beyond the predictions of standard stellar theory.
Aims: We study the effects of thermohaline instability and rotation-induced mixing in the 1–4 $M_\odot$ range at solar metallicity.
Methods: We present evolutionary models by considering both thermohaline and rotation-induced mixing in stellar interior. We discuss the effects of these processes on the chemical properties of stars from the zero age main sequence up to the end of the second dredge-up on the early-AGB for intermediate-mass stars and up to the AGB tip for low-mass stars. Model predictions are compared to observational data for lithium, ^{12}C/^{13}C, [N/C], [Na/Fe], ^{16}O/^{17}O, and ^{16}O/^{18}O in Galactic open clusters and in field stars with well-defined evolutionary status, as well as in planetary nebulae.
Results: Thermohaline mixing simultaneously accounts for the observed behaviour of ^{12}C/^{13}C, [N/C], and lithium in low-mass stars that are more luminous than the RGB bump, and its efficiency is increasing with decreasing initial stellar mass. On the TP-AGB, thermohaline mixing leads to lithium production, although the ^{7}Li yields remain negative. Although the ^{3}He stellar yields are much reduced thanks to this process, we find that solar-metallicity, low-mass stars remain net ^{3}He producers. Rotation-induced mixing is found to change the stellar structure so that in the mass range between ~1.5 and 2.2 $M_\odot$ the thermohaline instability occurs earlier on the red giant branch than in non-rotating models. Finally rotation accounts for the observed star-to-star abundance variations at a given evolutionary status, and is necessary to explain the features of CN-processed material in intermediate-mass stars.
Conclusions: Overall, the present models account for the observational constraints very well over the whole mass range presently investigated.

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Thermohaline instability and rotation-induced mixing. II. Yields of ^{3}He for low-and intermediate-mass stars

N. Lagarde[1], *C. Charbonnel*[1,2], *T. Decressin*[1] *and J. Hagelberg*[1]

[1]Geneva Observatory, University of Geneva, Chemin des Maillettes 51, 1290 Versoix, Switzerland

[2]IRAP, UMR 5277 CNRS and Université de Toulouse, 14 Av. E. Belin, 31400 Toulouse, France

Context: The ^{3}He content of Galactic H II regions is very close to that of the Sun and the solar system, and only slightly higher than the primordial ^{3}He abundance as predicted by the standard Big Bang nucleosynthesis. However, the classical theory of stellar evolution predicts a high production of ^{3}He by low-mass stars, implying a strong increase of ^{3}He with time in the Galaxy. This is the well-known "^{3}He problem".
Aims: We study the effects of thermohaline and rotation-induced mixings on the production and destruction of ^{3}He over the lifetime of low- and intermediate-mass stars at various metallicities.
Methods: We compute stellar evolutionary models in the mass range 1 to 6 $M_\odot$ for four metallicities, taking into account thermohaline instability and rotation-induced mixing. For the thermohaline diffusivity we use the prescription based on the linear stability analysis, which reproduces Red Giant Branch (RGB) abundance patterns at all metallicities. Rotation-induced mixing is treated taking into account meridional circulation and shear turbulence. We discuss the effects of these processes on internal and surface abundances of ^{3}He and on the net yields.
Results: Over the whole mass and metallicity range investigated, rotation-induced mixing lowers the ^{3}He production, as well as the upper mass limit at which stars destroy ^{3}He. For low-mass stars, thermohaline mixing occuring beyond the RGB bump is the dominant process in strongly reducing the net ^{3}He yield compared to standard computations. Yet these stars remain net ^{3}He producers.
Conclusions: Overall, the net ^{3}He yields are strongly reduced compared to the standard framework predictions.

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Thermohaline instability and rotation-induced mixing. III. Grid of stellar models and asymptotic asteroseismic quantities from the pre-main sequence up to AGB for low-and intermediate-mass stars at various metallicities

N. Lagarde[1], *T. Decressin*[1], *C. Charbonnel*[1,2], *P. Eggenberger*[1], *S. Ekström*[1] *and A. Palacios*[3]

[1]Geneva Observatory, University of Geneva, Chemin des Maillettes 51, 1290 Versoix, Switzerland

[2]IRAP, UMR 5277 CNRS and Université de Toulouse, 14 Av. E. Belin, 31400 Toulouse, France

[3]LUPM, Université Montpellier II, CNRS, UMR 5299, Place E. Bataillon, 34095 Montpellier, France

Context: The availability of asteroseismic constraints for a large sample of stars from the missions CoRoT and *Kepler* paves the way for various statistical studies of the seismic properties of stellar populations.
Aims: In this paper, we evaluate the impact of rotation-induced mixing and thermohaline instability on the global asteroseismic parameters at different stages of the stellar evolution from the Zero Age Main Sequence to the Thermally Pulsating Asymptotic Giant Branch to distinguish stellar populations.
Methods: We present a grid of stellar evolutionary models for four metallicities ($Z = 0.0001$, 0.002, 0.004, and 0.014) in the mass range between 0.85 to 6.0 $M_\odot$. The models are computed either with standard prescriptions or including both thermohaline convection and rotation-induced mixing. For the whole grid we provide the usual stellar parameters (luminosity, effective temperature, lifetimes, ...), together with the global seismic parameters, i.e. the large frequency separation and asymptotic relations, the frequency corresponding to the maximum oscillation power $\nu_{\rm max}$, the maximal amplitude $A_{\rm max}$, the asymptotic period spacing of g-modes, and different acoustic radii.
Results: We discuss the signature of rotation-induced mixing on the global asteroseismic quantities, that can be detected observationally. Thermohaline mixing whose effects can be identified by spectroscopic studies cannot be characterized with the global seismic parameters studied here. But it is not excluded that individual mode frequencies or other well chosen asteroseismic quantities might help constraining this mixing.

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Effects of thermohaline instability and rotation-induced mixing on the evolution of light elements in the Galaxy : D, ^{3}He, and ^{4}He

N. Lagarde[1], *D. Romano*[2], *C. Charbonnel*[1,3], *M. Tosi*[2], *C. Chippini*[4] *and F. Matteucci*[5,6]

[1]Geneva Observatory, University of Geneva, Chemin des Maillettes 51, 1290 Versoix, Switzerland

[2]INAF–Bologna Observatory, via Ranzani 1, I-40127, Bologna, Italy

[3]IRAP, CNRS UMR 5277, Université de Toulouse, 14 Av. E.Belin, 31400 Toulouse, France

[4]Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16 D-14482, Potsdam, Germany

[5]Physics Department, Trieste University, via Tiepolo 11, I-34143 Trieste, Italy

[6]INAF–Trieste Observatory, via Tiepolo 11, I-34143 Trieste, Italy

Context: Recent studies of low- and intermediate-mass stars show that the evolution of the chemical elements in these stars is very different from that proposed by standard stellar models. Rotation-induced mixing modifies the internal chemical structure of main sequence stars, although its signatures are revealed only later in the evolution when the first dredge-up occurs. Thermohaline mixing is likely the dominating process that governs the photospheric composition of low-mass red giant branch stars and has been shown to drastically reduce the net ^{3}He production in these stars. The predictions of these new stellar models need to be tested against galaxy evolution. In particular, the resulting evolution of the light elements D, ^{3}He and ^{4}He should be compared with their primordial values inferred from the Wilkinson Microwave Anisotropy Probe data and with the abundances derived from observations of different Galactic regions.
Aims: We study the effects of thermohaline mixing and rotation-induced mixing on the evolution of the light elements in the Milky Way.
Methods: We compute Galactic evolutionary models including new yields from stellar models computed with thermohaline instability and rotation-induced mixing. We discuss the effects of these important physical processes acting in stars on the evolution of the light elements D, ^{3}He, and ^{4}He in the Galaxy.
Results: Galactic chemical evolution models computed with stellar yields including thermohaline mixing and rotation fit better observations of ^{3}He and ^{4}He in the Galaxy than models computed with standard stellar yields.
Conclusions: The inclusion of thermohaline mixing in stellar models provides a solution to the long standing "^{3}He problem" on a Galactic scale. Stellar models including rotation-induced mixing and thermohaline instability reproduce also the observations of D and ^{4}He.

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The chemical diversity of exo-terrestrial planetary debris around white dwarfs

B.T. Gänsicke[1], *D. Koester*[2], *J. Farihi*[3], *J. Girven*[1], *S.G. Parsons*[1] *and E. Breedt*[1]

[1]Department of Physics, University of Warwick, Coventry CV4 7AL, UK

[2]Institut für Theoretische Physik und Astrophysik, University of Kiel, 24098 Kiel, Germany

[3]Department of Physics Astronomy, University of Leicester, Leicester LE1 7RH, UK

We present *Hubble Space Telescope* ultraviolet spectroscopy of the white dwarfs PG 0843+516, PG 1015+161, SDSS 1228 +1040, and GALEX 1931+0117, which accrete circumstellar planetary debris formed from the destruction of asteroids. Combined with optical data, a minimum of five and a maximum of eleven different metals are detected in their photospheres. With metal sinking time scales of only a few days, these stars are in accretion/diffusion equilibrium, and the photospheric abundances closely reflect those of the circumstellar material. We find C/Si ratios that are consistent with that of the bulk Earth, corroborating the rocky nature of the debris. Their C/O values are also very similar to

those of bulk Earth, implying that the planetary debris is dominated by Mg and Fe silicates. The abundances found for the debris at the four white dwarfs show substantial diversity, comparable at least to that seen across different meteorite classes in the solar system. PG 0843+516 exhibits significant over-abundances of Fe and Ni, as well as of S and Cr, which suggests the accretion of material that has undergone melting, and possibly differentiation. PG 1015+161 stands out by having the lowest Si abundance relative to all other detected elements. The Al/Ca ratio determined for the planetary debris around different white dwarfs is remarkably similar. This is analogous to the nearly constant abundance ratio of these two refractory lithophile elements found among most bodies in the solar system.
Based on the detection of all major elements of the circumstellar debris, we calculate accretion rates of $\simeq 1.7 \times 10^8$ g s^{-1} to $\simeq 1.5 \times 10^9$ g s^{-1}. Finally, we detect additional circumstellar absorption in the Si IV 1394,1403 doublet in PG 0843+516 and SDSS 1228+1040, reminiscent to similar high-ionisation lines seen in the *HST* spectra of white dwarfs in cataclysmic variables. We suspect that these lines originate in hot gas close to the white dwarf, well within the sublimation radius.

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Limits on [O III] 5007 emission from NGC 4472's globular clusters: constraints on planetary nebulae and ultraluminous black hole X-ray binaries in globular clusters

Mark B. Peacock[1], *Stephen E. Zepf*[1] *and Thomas J. Maccarone*[2]

[1]Michigan State University, USA
[2]University of Southampton, UK

We have searched for [O III] 5007 emission in high resolution spectroscopic data from Flames/Giraffe VLT observations of 174 massive globular clusters (GCs) in NGC 4472. No planetary nebulae (PNe) are observed in these clusters, constraining the number of PNe per bolometric luminosity, $\alpha < 0.8 \times 10^{-7}$ PN $L_\odot^{-1}$. This is significantly lower than the rate predicted from stellar evolution, if all stars produce PNe. Comparing our results to populations of PNe in galaxies, we find most galaxies have a higher α than these GCs (more PNe per bolometric luminosity – though some massive early-type galaxies do have similarly low α). The low α required in these GCs suggests that the number of PNe per bolometric luminosity does not increase strongly with decreasing mass or metallicity of the stellar population. We find no evidence for correlations between the presence of known GC PNe and either the presence of low mass X-ray binaries (LMXBs) or the stellar interaction rates in the GCs. This, and the low α observed, suggests that the formation of PNe may not be enhanced in tight binary systems. These data do identify one [O III] emission feature, this is the (previously published) broad [O III] emission from the cluster RZ 2109. This emission is thought to originate from the LMXB in this cluster, which is accreting at super-Eddington rates. The absence of any similar [O III] emission from the other clusters favors the hypothesis that this source is a black hole LMXB, rather than a neutron star LMXB with significant geometric beaming of its X-ray emission.

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The *Chandra* X-ray Survey of Planetary Nebulae (ChanPlaNS): Probing binarity, magnetic fields, and wind collisions

J.H. Kastner[1], *R. Montez Jr.*[1], *B. Balick*[2], *D.J. Frew*[3], *B. Miszalski*[4,5], *R. Sahai*[6], *E. Blackman*[7], *Y.-H. Chu*[8], *O. De Marco*[3], *A. Frank*[7], *M.A. Guerrero*[9], *J. A. Lopez*[10], *V. Rapson*[1], *A.A. Zijlstra*[11], *E. Behar*[12], *V. Bujarrabal*[13], *R.L.M. Corradi*[14,15], *J. Nordhaus*[16], *Q. Parker*[3], *C. Sandin*[17], *D. Schönberner*[17], *N. Soker*[12], *J.L. Sokoloski*[18], *M. Steffen*[17], *T. Ueta*[19] *and E. Villaver*[20]

[1]Center for Imaging Science and Laboratory for Multiwavelength Astrophysics, Rochester Institute of Technology, 54 Lomb Memorial Drive, Rochester NY 14623, USA (jhk@cis.rit.edu)

[2]Dept. of Astronomy, University of Washington, Seattle, WA, USA

[3]Department of Physics & Astronomy and Macquarie Research Centre for Astronomy, Astrophysics & Astrophotonics, Macquarie University, Sydney, NSW 2109, Australia

[4]South African Astronomical Observatory, P.O. Box 9, Observatory, 7935, South Africa

[5]Southern African Large Telescope Foundation, P.O. Box 9, Observatory, 7935, South Africa

[6]Jet Propulsion Laboratory, MS 183-900, California Institute of Technology, Pasadena, CA 91109, USA

[7]Dept. of Physics & Astronomy, University of Rochester, Rochester, NY, USA

[8]Dept. of Astronomy, University of Illinois, Champagne-Urbana, IL, USA

[9]Instituto de Astrofísica de Astronomía, Glorieta de la Astronomía s/n, Granada, 18008 Spain

[10]Instituto de Astronomía, Universidad Nacional Autónoma de México, Campus Ensenada, Apdo. Postal 22860, Ensenada, B.C., México

[11]School of Physics and Astronomy, University of Manchester, Manchester M13 9PL, UK

[12]Department of Physics, Technion, Israel (soker@physics.technion.ac.il)

[13]Observatorio Astronómico Nacional, Apartado 112, E-28803, Alcala de Henares, Spain

[14]Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain

[15]Departamento de Astrofísica, Universidad de La Laguna, E-38206 La Laguna, Tenerife, Spain

[16]NSF Astronomy and Astrophysics Fellow, Center for Computational Relativity and Gravitation, Rochester Institute of Technology, Rochester, NY 14623, USA

[17]Leibniz Institute for Astrophysics Potsdam (AIP), An der Sternwarte 16, D-14482 Potsdam, Germany

[18]Columbia Astrophysics Laboratory, Columbia University, New York, NY 10027, USA

[19]Dept. of Physics & Astronomy, University of Denver, Denver, CO 80208, USA

[20]Departamento de Física Teórica, Universidad Autónoma de Madrid, Cantoblanco 28049 Madrid, Spain

We present an overview of the initial results from the *Chandra* Planetary Nebula Survey (ChanPlaNS), the first systematic (volume-limited) *Chandra* X-ray Observatory survey of planetary nebulae (PNe) in the solar neighborhood. The first phase of ChanPlaNS targeted 21 mostly high-excitation PNe within ~ 1.5 kpc of Earth, yielding three detections of diffuse X-ray emission and nine detections of X-ray-luminous point sources at the central stars (CSPNe) of these objects. Combining these results with those obtained from *Chandra* archival data for all (14) other PNe within ~ 1.5 kpc that have been observed to date, we find an overall X-ray detection rate of 68%. Roughly 50% of the PNe observed by *Chandra* harbor X-ray-luminous CSPNe, while soft, diffuse X-ray emission tracing shocks – in most cases, "hot bubbles" – formed by energetic wind collisions is detected in $\sim 30\%$; five objects display both diffuse and point-like emission components. The presence (or absence) of X-ray sources appears correlated with PN density structure, in that molecule-poor, elliptical nebulae are more likely to display X-ray emission (either point-like or diffuse) than molecule-rich, bipolar or Ring-like nebulae. All but one of the X-ray point sources detected at CSPNe display X-ray spectra that are harder than expected from hot (~ 100 kK) central stars emitting as simple blackbodies; the lone apparent exception is the central star of the Dumbbell nebula, NGC 6853. These hard X-ray excesses may suggest a high frequency of binary companions to CSPNe. Other potential explanations include self-shocking winds, non-LTE photospheric emission from the CSPN, or PN mass fallback. Most PNe detected as diffuse X-ray sources are elliptical nebulae that display a nested shell/halo structure and bright ansæ; the diffuse X-ray emission regions are confined within inner, sharp-rimmed shells. All sample PNe that display diffuse X-ray emission have inner shell dynamical ages $\lesssim 5 \times 10^3$ yr, placing firm constraints on the timescale for strong shocks due to wind interactions in PNe. The high-energy emission arising in such wind shocks may contribute to the high excitation states of certain archetypical "hot bubble" nebulae (e.g., NGC 2392, 3242, 6826, and 7009).

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Scars of intense accretion episodes at metal-rich white dwarfs

J. Farihi[1], *B.T. Gänsicke*[2], *M.A. Wyatt*[3], *J. Girven*[2], *J.E. Pringle*[1,3] *and A.R. King*[1]

[1]University of Leicester, UK
[2]University of Warwick, UK
[3]University of Cambridge, UK

A re-evaluation of time-averaged accretion rates at DBZ-type white dwarfs points to historical, time-averaged rates significantly higher than the currently observed episodes at their DAZ counterparts. The difference between the ongoing, instantaneous accretion rates witnessed at DAZ white dwarfs, which often exceed 10^8 g s^{-1}, and those inferred over the past 10^{5-6} yr for the DBZ stars can be a few orders of magnitude, and therefore must result from high-rate episodes of tens to hundreds of years so they remain undetected to date. This paper explores the likelihood that such brief, intense accretion episodes of gas-phase material can account for existing data. For reasonable assumptions about the circumstellar gas, accretion rates approaching or exceeding 10^{15} g s^{-1} are possible, similar to rates observed in quiescent cataclysmic variables, and potentially detectable with future x-ray missions or wide-field monitoring facilities. Gaseous debris that is prone to such rapid accretion may be abundant immediately following a tidal disruption event via collisions and sublimation, or if additional bodies impinge upon an extant disk. Particulate disk matter accretes at or near the Poynting–Robertson drag rate for long periods between gas-producing events, consistent with rates inferred for dusty DAZ white dwarfs. In this picture, warm DAZ stars without infrared excesses have rates consistent with accretion from particulate disks that remain undetected. This overall picture has implications for quasi-steady state models of accretion and the derived chemical composition of asteroidal debris in DBZ white dwarfs.

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Precision astrometry of the exoplanet host candidate GD 66

J. Farihi[1], *J.P. Subasavage*[2], *E.P. Nelan*[3], *H.C. Harris*[2], *C.C. Dahn*[2], *J. Nordhaus*[4] *and D.S. Spiegel*[5]

[1]University of Leicester, UK
[2]U.S. Naval Observatory, USA
[3]Space Telescope Science Institute, USA
[4]Rochester Institute of Technology, USA
[5]Institute for Advanced Study, USA

The potential existence of a giant planet orbiting within a few AU of a stellar remnant has profound implications for both the survival and possible regeneration of planets during post-main sequence stellar evolution. This paper reports *Hubble* Space Telescope Fine Guidance Sensor and U.S. Naval Observatory relative astrometry of GD 66, a white dwarf thought to harbor a giant planet between 2 and 3 AU based on stellar pulsation arrival times. Combined with existing infrared data, the precision measurements here rule out all stellar-mass and brown dwarf companions, implying that only a planet remains plausible, if orbital motion is indeed the cause of the variations in pulsation timing.

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The mass-loss return from evolved stars to the Large Magellanic Cloud. VI: Luminosities and mass-loss rates on population scales

D. Riebel[1], *S. Srinivasan*[2], *B. Sargent*[3,4] *and M. Meixner*[4,1]

[1]Department of Physics and Astronomy, The Johns Hopkins University, 3400 North Charles St. Baltimore, MD 21218, USA
[2]UPMC–CNRS UMR7095, Institut d'Astrophysique de Paris, F-75014 Paris, France
[3]Center for Imaging Science and Laboratory for Multiwavelength Astrophysics, Rochester Institute of Technology, 54 Lomb Memorial Drive, Rochester, NY 14623, USA
[4]Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

We present results from the first application of the Grid of Red Supergiant and Asymptotic Giant Branch ModelS

(GRAMS) model grid to the entire evolved stellar population of the Large Magellanic Cloud (LMC). GRAMS is a pre-computed grid of 80,843 radiative transfer (RT) models of evolved stars and circumstellar dust shells composed of either silicate or carbonaceous dust. We fit GRAMS models to $\sim 30,000$ Asymptotic Giant Branch (AGB) and Red Supergiant (RSG) stars in the LMC, using 12 bands of photometry from the optical to the mid-infrared. Our published dataset consists of thousands of evolved stars with individually determined evolutionary parameters such as luminosity and mass-loss rate. The GRAMS grid has a greater than 80% accuracy rate discriminating between oxygen- and carbon-rich chemistry. The global dust injection rate to the interstellar medium (ISM) of the LMC from RSGs and AGB stars is on the order of 1.5×10^{-5} M$_\odot$ yr^{-1}, equivalent to a total mass injection rate (including the gas) into the ISM of $\sim 5 \times 10^{-3}$ M$_\odot$ yr^{-1}. Carbon stars inject two and a half times as much dust into the ISM as do O-rich AGB stars, but the same amount of mass. We determine a bolometric correction factor for C-rich AGB stars in the K band as a function of J–K color, $BC(K) = -0.40(J-K)^2 + 1.83(J-K) + 1.29$. We determine several IR color proxies for the dust mass-loss rate (MLR) from C-rich AGB stars, such as $\log(MLR) = -18.90/((K-[8.0]) + 3.37) - 5.93$. We find that a larger fraction of AGB stars exhibiting the 'long-secondary period' phenomenon are O-rich than stars dominated by radial pulsations, and AGB stars without detectable mass-loss do not appear on either the first-overtone or fundamental-mode pulsation sequences.

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Further investigation of white dwarfs in the open clusters NGC 2278 and NGC 3532

P.D. Dobbie[1], A. Day-Jones[2], K.A. Williams[3], S.L.Casewell[4], M.R. Burleigh[4], N. Lodieu[5], Q.A. Parker[6] and R. Baxter[6]

[1]Univeristy of Tasmania, Australia
[2]Universidad de Chile, Chile
[3]Texas A & M University–Commerce, USA
[4]University of Leicester, UK
[5]IAC Tenerife, Spain
[6]Macquarie University, Australia

We report the results of a CCD imaging survey, complimented by astrometric and spectroscopic follow-up studies, that aims to probe the fate of heavy-weight intermediate mass stars by unearthing new, faint, white dwarf members of the rich, nearby, intermediate age open clusters NGC 3532 and NGC 2287. We identify a total of four white dwarfs with distances, proper motions and cooling times which can be reconciled with membership of these populations. We find that WD J0643−203 in NGC 2287, with an estimated mass of $M = 1.02$–1.16 M$_\odot$, is potentially the most massive white dwarf so far identified within an open cluster. Guided by the predictions of modern theoretical models of the late-stage evolution of heavy-weight intermediate mass stars, we conclude that there is a distinct possibility it has a core composed of O and Ne. We also determine that despite the cooling times of the three new white dwarfs in NGC 3532 and the previously known degenerate member NGC 3532-10 spanning ~ 90 Myr, they all have remarkably similar masses ($M \sim 0.9$–1 M$_\odot$). This is fully consistent with the results from our prior work on a heterogeneous sample of ~ 50 white dwarfs from 12 stellar populations, on the basis of which we argued that the stellar initial mass–final mass relation is less steep at $M_{\rm init} > 4$ M$_\odot$ than in the adjacent lower initial mass regime. This change in the gradient of the relation could account for the secondary peak observed in the mass distribution of the field white dwarf population and mitigate the need to invoke close binary evolution to explain its existence. Spectroscopic investigation of numerous additional candidate white dwarf members of NGC 3532 unearthed by a recent independent study would be useful to confirm (or otherwise) these conclusions.

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Life after eruption – I. Spectroscopic observations of ten nova candidates

C. Tappert[1], *A. Ederoclite*[2], *R.E. Mennickent*[3], *L. Schmidtobreick*[4] *and N. Vogt*[1]

[1]Dpto. de Física y Astronomía, Universidad de Valparaíso, Chile
[2]Centro de Estudios de Física del Cosmos de Aragón, Spain
[3]Dpto. de Astronomía, Universidad de Concepción, Chile
[4]European Southern Observatory, Santiago, Chile

We have started a project to investigate the connection of post-novae with the population of cataclysmic variables. Our first steps in this concern improving the sample of known post-novae and their properties. Here we present the recovery and/or confirmation of the old novae MT Cen, V812 Cen, V655 CrA, IL Nor, V2109 Oph, V909 Sgr, V2572 Sgr, and V728 Sco. Principal photometric and spectroscopic properties of these systems are discussed. We find that V909 Sgr is a probable magnetic CV, and that V728 Sco is a high-inclination system. We furthermore suggest that the two candidate novae V734 Sco and V1310 Sgr have been misclassified and instead are Mira variables.

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[Fe III] emission lines in the planetary nebula NGC 2392

Yong Zhang[1], *Xuan Fang*[2], *Wayne Chau*[1], *Chih-Hao Hsia*[1], *Xiao-Wei Liu*[2], *Kwok Sun*[1] *and Nico Koning*[3]

[1]Department of Physics, The University of Hong Kong, China
[2]Department of Astronomy, Peking University, China
[3]Department of Physics and Astronomy, University of Calgary, Canada

NGC 2392 is a young double-shell planetary nebula (PN). Its intrinsic structure and shaping mechanism are still not fully understood. In this paper we present new spectroscopic observations of NGC 2392. The slits were placed at two different locations to obtain the spectra of the inner and outer regions. Several [Fe III] lines are clearly detected in the inner region. We infer that NGC 2392 might have an intrinsic structure similar to the bipolar nebula Mz 3, which also exhibits a number of [Fe III] lines arising from the central regions. In this scenario, the inner and outer regions of NGC 2392 correspond to the inner lobes and the outer outflows of Mz 3, respectively. We construct a three-dimensional morpho-kinematic model to examine our hypothesis. We also compare the physical conditions and chemical composition of the inner and outer regions, and discuss the implications on the formation of this type of PN.

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The period–luminosity relation of red supergiant stars in the Small Magellanic Cloud

Ming Yang[1] *and Biwei Jiang*[1]

[1]Department of Astronomy, Beijing Normal University, China

The characteristics of light variation of RSGs in SMC are analyzed based on the nearly 8–10 year long data collected by the ASAS and MACHO projects. The identified 126 RSGs are classified into five categories accordingly: 20 with poor photometry, 55 with no reliable period, 6 with semi-regular variation, 15 with Long Secondary Period (LSP) and distinguishable short period and 30 with only LSP. For the semi-regular variables and the LSP variables with distinguishable short period, the K_s-band period–luminosity (P–L) relation is analyzed and compared with that of the Galaxy, LMC and M 33. It is found that the RSGs in these galaxies obey similar P–L relation except the Galaxy. In addition, the P–L relations in the infrared bands, namely the 2MASS JHK_s, *Spitzer*/IRAC and *Spitzer*/MIPS 24-μm bands, are derived with high reliability. The best P–L relation occurs in the *Spitzer*/IRAC [3.6] and [4.5] bands.

Based on the comparison with the theoretical calculation of the P–L relation, the mode of pulsation of RSGs in SMC is suggested to be the first overtone radial mode.

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Discovery of super-Li rich red giants in dwarf spheroidal galaxies

Evan Kirby[1], Xiaoting Fu[2], Puragra Guhathakurta[3] and Licai Deng[2]

[1]Caltech, USA
[2]NAOC, China
[3]UC Santa Cruz, USA

Stars destroy lithium (Li) in their normal evolution. The convective envelopes of evolved red giants reach temperatures of millions of K, hot enough for the ^{7}Li(p,α)^{4}He reaction to burn Li efficiently. Only about 1% of first-ascent red giants more luminous than the luminosity function bump in the red giant branch exhibit $A(\mathrm{Li}) > 1.5$. Nonetheless, Li-rich red giants do exist. We present 15 Li-rich red giants – 14 of which are new discoveries – among a sample of 2054 red giants in Milky Way dwarf satellite galaxies. Our sample more than doubles the number of low-mass, metal-poor ([Fe/H] $\lesssim -0.7$) Li-rich red giants, and it includes the most-metal poor Li-enhanced star known ([Fe/H] $= -2.82$, $A(\mathrm{Li})_{\mathrm{NLTE}} = 3.15$). Because most of these stars have Li abundances larger than the Universe's primordial value, the Li in these stars must have been created rather than saved from destruction. These Li-rich stars appear like other stars in the same galaxies in every measurable regard other than Li abundance. We consider the possibility that Li enrichment is a universal phase of evolution that affects all stars, and it seems rare only because it is brief.

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Chemical abundances of hot post-AGB stars

D.R.C. Mello[1], S. Daflon[1], C.B. Pereira[1] and I. Hubeny[2]

[1]Observatório Nacional/MCTI, Rua Gen. José Cristino, 77, CEP:20921400, São Cristovão – Rio de Janeiro, Brazil
[2]Steward Observatory and Department of Astronomy, University of Arizona, Tucson, AZ 85721, USA

Hot post-AGB stars are luminous objects of low- and intermediate-mass (0.8–8 $M_\odot$) in the final stage of evolution, moving between the AGB (asymptotic giant branch) stars and planetary nebulae. The absorption lines observed in their spectra are typical of early-type stars and their abundance pattern may be associated with the occurrence of one or more mixing processes during the previous AGB phase. To better constrain their observed chemical pattern and evolutionary status, we determined chemical abundances for a sample of hot post-AGB stars selected according to spectroscopic criteria. The observational data are high-resolution spectra obtained with the FEROS spectrograph. The stellar parameters and chemical composition were obtained from fully consistent non-LTE synthesis. The general abundance pattern reveals relevant nitrogen enrichment, slight depletion in carbon and sulfur and mild excess in helium for most of the objects. One notable exception is LSE 148, with $Z = 0.001$, which is likely to be a metal-poor object at high Galactic latitude. The atmospheric parameters and chemical abundances obtained are discussed in the context of evolutionary models. Mixing processes like the second/third dredged-up and "hot bottom burning" are invoked to explain the obtained results.

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The inner wind of IRC $+10^{\circ}216$ revisited: New exotic chemistry and diagnostic for dust condensation in carbon stars

Isabelle Cherchneff[1]

[1]Physics Department, University of Basel, Switzerland

Context: We model the chemistry of the inner wind of the carbon star IRC $+10^{\circ}216$ and consider the effects of periodic shocks induced by the stellar pulsation on the gas to follow the non-equilibrium chemistry in the shocked gas layers. We consider a very complete set of chemical families, including hydrocarbons and aromatics, hydrides, halogens, and phosphorous-bearing species. Our derived abundances are compared to those for the latest observational data from large surveys and the *Herschel* telescope.
Methods: A semi-analytical formalism based on parameterised fluid equations is used to describe the gas density, velocity, and temperature from 1 $R_{\star}$ to 5 $R_{\star}$. The chemistry is described using a chemical kinetic network of reactions and a set of stiff, ordinary, coupled differential equations is solved.
Results: The shocks induce an active non-equilibrium chemistry in the dust formation zone of IRC $+10^{\circ}216$ where the collision destruction of CO in the post-shock gas triggers the formation of O-bearing species such as H_2O and SiO. Most of the modelled molecular abundances agree very well with the latest values derived from *Herschel* data on IRC $+10^{\circ}216$. The hydrides form a family of abundant species that are expelled into the intermediate envelope. In particular, HF traps all the atomic fluorine in the dust formation zone. The halogens are also abundant and their chemistry is independent of the C/O ratio of the star. Therefore, HCl and other Cl-bearing species should also be present in the inner wind of O-rich AGB or supergiant stars. We identify a specific region ranging from 2.5 $R_{\star}$ to 4 $R_{\star}$, where polycyclic aromatic hydrocarbons form and grow. The estimated carbon dust-to-gas mass ratio derived from the mass of aromatics formed ranges from 1.2×10^{-3} to 5.8×10^{-3} and agrees well with existing values deduced from observations. This aromatic formation region is situated outside hot layers where SiC_2 is produced as a by-product of silicon carbide dust synthesis. The MgS grains can form from the gas phase but in lower quantities than those necessary to reproduce the strength of the 30-μm emission band. Finally, we predict that some molecular lines will show a flux variation with pulsation phase and time (e.g., H_2O), while other species will not (e.g., CO). These variations merely reflect the non-equilibrium chemistry that destroys and reforms molecules over a pulsation period in the shocked gas of the dust formation zone.

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The nature of dust in compact Galactic planetary nebulae from *Spitzer* spectra

L. Stanghellini[1], *D.A. García-Hernández*[2], *P. García-Lario*[3], *J.E. Davies*[4], *R.A. Shaw*[1], *E. Villaver*[5], *A. Manchado*[2] *and J.V. Perea-Calderón*[6]

[1]NOAO, USA
[2]IAC–ULL, Spain
[3]ESAC–ESA, Spain
[4]*Spitzer* Science Center–CIT, USA
[5]UAM, Spain
[6]INSA–ESAC, Spain

We present the *Spitzer*/IRS spectra of 157 compact Galactic planetary nebulae (PNe). These young PNe provide insight on the effects of dust in early post-AGB evolution, before much of the dust is altered or destroyed by the hardening stellar radiation field. Most of the selected targets have PN-type IRS spectra, while a few turned out to be misclassified stars. We inspected the group properties of the PN spectra and classified them based on the different dust classes (featureless, or F; carbon-rich dust, or CRD; oxygen-rich dust, or ORD; mixed-chemistry dust, or MCD) and subclasses (aromatic and aliphatic; crystalline and amorphous). All PNe are characterized by dust continuum and more than 80% of the sample shows solid state features above the continuum, in contrast with the Magellanic Cloud sample where only $\sim 40\%$ of the entire sample displays solid state features; this is an indication of the strong link between dust properties and metallicity. The Galactic PNe that show solid state features are almost equally divided among the CRD, ORD, and MCD. We analyzed dust properties together with other PN properties and found that (i) there is an enhancement of MCD PNe toward the Galactic center, in agreement with studies of Galactic bulge PNe; (ii) CRD PNe could be seen as defining an evolutionary sequence, contrary to the ORD and MCD PNe, which are scattered in all evolutionary diagrams; (iii) carbon-rich and oxygen-rich grains retain different equilibrium temperatures, as expected from models; (iv) ORD PNe are highly asymmetric, i.e. bipolar or bipolar-core, and CRD PNe highly symmetric, i.e. round or elliptical; point-symmetry is statistically more common in MCD than in other dust class PNe. By comparing the sample of this paper to that of Magellanic Cloud PNe we find that the latter sample does not include MCD PNe, and the other dust classes are differently populated, with continuity of the fraction of F, CRD, ORD, and MCD population from high to low metallicity environments. We also find similar sequences for CRD PNe in the Galactic disk and the Magellanic Clouds, except that the Magellanic Cloud PNe seem to attain higher dust temperatures at similar evolutionary stages, in agreement with the observational findings of smaller dust grains (i.e. lower radiation efficiency) in low metallicity interstellar environments.

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The light element abundance distribution in NGC 5128 from planetary nebulae

J.R. Walsh[1], G.H. Jacoby[2], R.F. Peletier[3] and N.A. Walton[4]

[1]European Southern Observatory, Germany
[2]Giant Magellan Telescope Organization / Carnegie Observatories, USA
[3]Kapteyn Astronomical Institute, The Netherlands
[4]Institute of Astronomy, University of Cambridge, UK

The light element abundance pattern from many planetary nebulae (PNe) covering the upper 4 mag. of the [O III] luminosity function was observed with ESO VLT FORS1 multi-slit. Spectra of 51 PNe over the wavelength range 3500–7500 Å were obtained in three fields at 4, 8 and 17 kpc, for a distance of 3.8 Mpc. Emission line ratios are entirely typical of PN such as in the Milky Way. The temperature sensitive [O III] 4363Å line was weakly detected in 10 PNe, both [O II] and [O III] lines were detected in 30 PNe, and only the bright [O III] 5007Å line in 7 PN. CLOUDY photo-ionization models were run to match the spectra by a spherical, constant density nebula ionized by a black body central star. He, N, O and Ne abundances with respect to H were determined and, for brighter PNe, S and Ar; central star luminosities and temperatures are also derived. For 40 PNe with CLOUDY models, from the upper 2 mag. of the luminosity function, the most reliably estimated element, oxygen, has a mean $12+\log(\mathrm{O/H})$ of 8.52. No obvious radial gradient is apparent in O/H over a range 2–20 kpc. Comparison of the PN abundances with the stellar population, from the spectra of the integrated starlight on the multi-slits and photometric studies, suggests $[\mathrm{Fe/H}] = -0.4$ and $[\mathrm{O/Fe}] = 0.25$. The masses of the PN central stars in NGC 5128 from model tracks imply an epoch of formation more recent than for the minority young population from colour–magnitude studies. The PNe progenitors may belong to the young tail of a recent, minor, star formation episode or derive from other evolutionary channels. [Abridged]

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New bright carbon stars found In the DFBS

K.S. Gigoyan[1], C. Rossi[2], S. Sclavi[2] and S.Gaudenzi[2]

[1]V.A. Ambartsumian Byurakan Astrophysical Observatory, Armenia, email: kgigoyan@bao.sci.am
[2]Department of Physics, University La Sapienza, Piazza A. Moro 00185, Roma, Italy

Carbon rich stars of Population II, such as CH giants, can provide direct information on the role of low- to intermediate-mass stars of the Halo in early Galactic evolution. The first list of the faint high latitude C stars, found in the Digitized First Byurakan Survey is now available in the web. In the present work, we report the recent discovery of two additional

CH type C stars, not previously catalogued, detected on the DFBS plates with help of the image analysis softwares. Medium-resolution spectra confirm the C-rich nature for both of them. Using infrared color–magnitude relationship, we estimated the distances and K-band absolute magnitudes to the new objects.

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Principal component abundance analysis of microlensed Bulge dwarf and subgiant stars

Brett H. Andrews[1], David H. Weinberg[1,2], Jennifer A. Johnson[1,2], Thomas Bensby[3] and Sofia Feltzing[3]

[1]Department of Astronomy, The Ohio State University, 140 West 18th Avenue, Columbus, OH 43210, USA

[2]Center for Cosmology and Astro-Particle Physics, The Ohio State University, 191 West Woodruff Avenue, Columbus, OH 43210, USA

[3]Lund Observatory, Department of Astronomy and Theoretical Physics, Box 43, SE-22100 Lund, Sweden

Elemental abundance patterns can provide vital clues to the formation and enrichment history of a stellar population. Here we present an investigation of the Galactic Bulge, where we apply principal component abundance analysis (PCAA) – a principal component decomposition of relative abundances $[X/\mathrm{Fe}]$ – to a sample of 35 microlensed Bulge dwarf and subgiant stars, characterizing their distribution in the 12-dimensional space defined by their measured elemental abundances. The first principal component PC1, which suffices to describe the abundance patterns of most stars in the sample, shows a strong contribution from α-elements, reflecting the relative contributions of Type II and Type Ia supernovae. The second principal component PC2 is characterized by a Na–Ni correlation, the likely product of metallicity-dependent Type II supernova yields. The distribution in PC1 is bimodal, showing that the bimodality previously found in the [Fe/H] values of these stars is robustly and independently recovered by looking at only their *relative* abundance patterns. The two metal-rich stars that are α-enhanced have outlier values of PC2 and PC3, respectively, further evidence that they have distinctive enrichment histories. Applying PCAA to a sample of local Thin and Thick Disk dwarfs yields a nearly identical PC1; in PC1, the metal-rich and metal-poor Bulge dwarfs track kinematically selected Thin and Thick Disk dwarfs, respectively, suggesting broadly similar α-enrichment histories. However, the disk PC2 is dominated by a Y–Ba correlation, likely indicating a greater contribution of s-process enrichment from asymptotic giant branch stars in the Disk, compared to the more rapidly forming Bulge.

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Near-infrared properties of asymptotic giant branch stars in nearby dwarf elliptical galaxy NGC 205

M.Y. Jung[1], Jongwan Ko[2,3], Jae-Woo Kim[4], Sang-Hyun Chun[1], Ho-Il Kim[3] and Y.-J. Sohn[1,2]

[1]Department of Astronomy, Yonsei University, Seoul 120-749, South Korea

[2]Yonsei University Observatory, Seoul 120-749, South Korea

[3]Korea Astronomy and Space Science Institute, Daejeon 305-348, South Korea

[4]CEOU, Department of Physics and Astronomy, Seoul National University, Seoul 151-742, South Korea

We investigated the distribution of resolved asymptotic giant branch (AGB) stars over a much larger area than covered by previous near-infrared studies in the nearby dwarf elliptical galaxy NGC 205. Using data obtained with the WIRCam near-infrared imager of the CFHT, we selected the AGB stars in the JHK_s color–magnitude diagrams, and separated the C stars from M-giant stars in the JHK_s color–color diagram. We identified 1,550 C stars in NGC 205 with a mean absolute magnitude of $\langle M_{K_\mathrm{s}}\rangle = -7.49 \pm 0.54$, and colors of $\langle (J-K_\mathrm{s})_0\rangle = 1.81 \pm 0.41$ and $\langle (H-K_\mathrm{s})_0\rangle = 0.76 \pm 0.24$. The ratio of C stars to M-giant stars was estimated to be 0.15 ± 0.01 in NGC 205, and the local C/M ratios for the southern region are somewhat lower than those for the northern region. The $(J-K_\mathrm{s})$ color distributions of AGB stars contain the main peak of the M-giant stars and the red tail of the C stars. A comparison of the theoretical isochrone models with the observed color distribution indicates that most of the bright M-giant stars in NGC 205 were formed

at $\log(t_{\rm yr}) \sim 9.0$–$9.7$. The logarithmic slope of the M_{K_s} luminosity function for M-giant stars was estimated to be 0.84 ± 0.01, which is comparable with dwarf elliptical galaxies NGC 147 and NGC 185. Furthermore, we found that the logarithmic slopes of the M_{K_s} luminosity function for C and M-giant stars are different to places, implying a different star formation history within NGC 205. The bolometric luminosity function for M-giant stars extends to $M_{\rm bol} = -6.0$ mag, and that for C stars spans $-5.6 < M_{\rm bol} < -3.0$. The bolometric luminosity function of C stars is unlikely to be a Gaussian distribution and the mean bolometric magnitude of C stars is estimated to be $M_{\rm bol} = -4.24 \pm 0.55$, which is consistent with our results for dwarf elliptical galaxies NGC 147 and NGC 185.

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Integrated J- and H-band spectra of globular clusters in the LMC: implications for stellar population models and galaxy age dating

Mariya Lyubenova[1], Harald Kuntschner[2], Marina Rejkuba[2], David R. Silva[3], Markus Kissler-Patig[2] and Lowell E. Tacconi-Garman[2]

[1]Max Planck Institute for Astronomy, Königstuhl 17, D-69117 Heidelberg, Germany

[2]European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching bei München, Germany

[3]National Optical Astronomy Observatory, 950 North Cherry Ave., Tucson, AZ, 85719, USA

(Abridged) The rest-frame near-IR spectra of intermediate age (1–2 Gyr) stellar populations are dominated by carbon based absorption features offering a wealth of information. Yet, spectral libraries that include the near-IR wavelength range do not sample a sufficiently broad range of ages and metallicities to allow for accurate calibration of stellar population models and thus the interpretation of the observations. In this paper we investigate the integrated J- and H-band spectra of six intermediate age (1–3 Gyr) and old (> 10 Gyr) globular clusters in the Large Magellanic Cloud, using observations obtained with the SINFONI IFU at the VLT. H-band C_2 and K-band ^{12}CO(2–0) feature strengths are compared to the models of Maraston (2005). C_2 is reasonably well reproduced by the models at all ages, while ^{12}CO(2–0) shows good agreement for older (age > 2 Gyr) populations, but the younger (1.3 Gyr) globular clusters do not follow the models. We argue that this is due to the fact that the empirical calibration of the models relies on only a few Milky Way carbon star spectra, which show different ^{12}CO(2–0) index strengths than the LMC stars. The C_2 absorption feature strength correlates strongly with age. It is present essentially only in populations that have 1–2 Gyr old stars, while its value is consistent with zero for older populations. The distinct spectral energy distribution observed for the intermediate age globular clusters in the J- and H-bands agrees well with the model predictions of Maraston for the contribution from the thermally pulsing asymptotic giant branch phase (TP-AGB). We show that the H-band C_2 absorption feature and the J-, H-band spectral shape can be used as an age indicator for intermediate age stellar populations in integrated spectra of star clusters and galaxies.

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The chemical composition of the post-AGB F-supergiant CRL 2688

M.N. Ishigaki[1], M. Parthasarathy[1,2], Bacham E. Reddy[3], P. García-Lario[4], Y. Takeda[1], W. Aoki[1], D.A. García-Hernández[5,6] and A. Manchado[5,6]

[1]National Astronomical Observatory of Japan, Japan

[2]Aryabhatta Research Institute of Observational Sciences, Nainital, India

[3]Indian Institute of Astrophysics, Bangalore 560034, India

[4]Herschel Science Centre, European Space Astronomy Centre, Spain

[5]Instituto de Astrofísica de Canarias, Spain

[6]Departamento de Astrofísica, Universidad de La Laguna, Spain

CRL 2688 (V1610 Cyg, Egg Nebula) is a bipolar proto-planetary nebula, which is thought to have recently moved off the asymptotic giant branch (AGB). Detailed abundance patterns of its photosphere and circumstellar material can

provide us with important clues to understand the nucleosynthesis, dredge-up and mixing experienced by the envelope of the central star during its AGB phase of evolution. We present an analysis of a high resolution ($R \sim 30\,000$) optical spectrum of the central region of CRL 2688. We confirm that the central star shows a spectrum typical of an F-type supergiant with $T_{\rm eff} = 7250 \pm 400$ K, $\log g = 0.5$ and [Fe/H] $= -0.3 \pm 0.1$ dex. We find that the abundance pattern of this object is characterized by enhancements of Carbon ([C/Fe] $= 0.6 \pm 0.1$), Nitrogen ([N/Fe] $= 1.0 \pm 0.3$) and Na ([Na/Fe] $= 0.7 \pm 0.1$), similar to other previously known carbon-rich post-AGB stars. Yttrium is also enhanced while the [Ba/Y] ratio is very low (-1.0), indicating that only the light s-process elements are enhanced. The Zinc abundance is found to be normal, [Zn/Fe] $= 0.0 \pm 0.3$, suggesting that there is no depletion of refractory elements. The Hα, Na I and K I resonance lines show prominent emission components, whose helio-centric radial velocities are offset by -41 ± 3 km s^{-1} relative to the photospheric metal-absorption lines. The molecular features of C_2 and CN also show emission components, whose velocities are consistent with the emission components of the Hα, Na I and K sc i lines. On the other hand, their absorption components are more highly blue shifted than the corresponding emission components, which suggests that the regions where the emission and absorption components arise are expanding at different velocities.

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Job Advert

Doctoral position on AGB stars and Optical Interferometry

The working group for Asymptotic Giant Branch Stars at the Institute of Astronomy, University of Vienna, is inviting applications for one Doctoral position in the area of stellar atmospheres and optical interferometry.

The position is for 3 years and candidates shall have some background in the theory and observation of stellar atmospheres and good programming skills. Knowledge of optical interferometry is an advantage but not required. The Ph.D. work shall be devoted to radiative transfer calculations based on dynamic model atmospheres and a comparison with existing and new interferometric data, in particular those acquired within our own ESO large program. The salary is about euro 19.000, – per annum (take home, no university fees).

The Institute of Astronomy offers a broad choice of astronomy education and research topics and a very good working environment. The interests and expertise of the AGB group comprise model atmospheres, molecular and dust spectroscopy, interferometry, abundance determinations, AGB stars in stellar systems, stellar variability, mass loss and laboratory astrophysics. The group collaborates with many researchers at international level and is involved in *Herschel*–PACS, MATISSE and ALMA. Further information can be found at www.univie.ac.at/astro.

The position is funded via an Austrian Science Fund project (see www.fwf.ac.at for financial details) and work should start in summer/fall 2012. Applications for the Ph.D. position should consist of a CV, publication list, a statement on the research interests and at least one reference letter.

The material should be sent by June 15, 2012 to:
Prof. Josef HRON
Institute of Astronomy
University of Vienna
Türkenschanzstraße 17
A-1180 Vienna
Austria
Fax number: +43-1-4277-9518
Questions about the position may be directed to josef.hron@univie.ac.at

See also www.univie.ac.at/astro

Announcements

Fizeau exchange visitors program – call for applications

Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff). Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is June 15 for visits between July 15 and December 31.

Further informations and application forms can be found at www.european-interferometry.eu

The program is funded by OPTICON/FP7.

Please distribute this message also to potentially interested colleagues outside of your community!

Looking forward to your applications,
Josef Hron & Laszlo Mosoni
(for the European Interferometry Initiative)

See also www.european-interferometry.eu

Radio Stars and Their Lives in the Galaxy

We are pleased to announce a three day workshop "Radio Stars and Their Lives in the Galaxy", to be held at Massachusetts Institute of Technology Haystack Observatory in Westford, Massachusetts, USA from October 3–5, 2012.

The goal of the workshop is to provide a forum for the presentation and discussion of the many advances in stellar and solar astrophysics recently (or soon to be) enabled by the latest generation of state-of-the-art radio facilities operating from meter to submillimeter wavelengths. We seek to bring together both observers and theorists to stimulate a lively exchange of ideas on how radio wavelength observations can provide new and unique insights into the workings of stars.

The deadline for abstract submission for contributed talks is June 15. For more information, please visit our web site.

See also http://www.haystack.mit.edu/workshop/Radio-Stars/